The "eyes" have it: Comparing pupillary responses to complex emotional stimuli in depressed and non-depressed individuals

Stewart, R.A., Hsu, K., Labrada, J., Foulser, A.A., Shumake, J., & Beevers, C.G.
Institute for Mental Health Research, The University of Texas at Austin

Background

- Cognitive models of depression suggest depression is associated with sustained processing of negative information, a potential risk and maintenance factor[1].
- Pupil dilation is thought to be a psychophysiological index of sustained cognitive processing[2,3], with depressed individuals commonly showing sustained pupil dilation to negative emotional information compared to healthy controls[4].
- Previous pupillometry studies in depressed populations have primarily utilized stimuli such as emotive faces or words, rather than more complex scenes that may be more representative of the real world[4,5]. In addition, previous studies have had relatively small samples sizes, limiting the power to detect more moderate effect sizes[4,5].

The current study sought to expand upon previous findings by comparing pupillary responses to more complex images in a large sample of depressed and non-depressed individuals. We also explored the role of arousal in pupillary response to emotional scenes.

Methods

Participants
Participants were adults between the ages of 18 and 55. The sample included 47 depressed and 46 healthy individuals recruited from the University of Texas at Austin and the greater Austin community (see Table 1).

Procedure
The present study examined pupillary responses while participants viewed a series of positive, negative, and neutral stimuli taken from the International Affective Picture System (IAPS)[6]. IAPS scenes are ranked according to the valence (unpleasant = 1 to pleasant = 9), and arousal (calm = 1, unpleasant = 9) of each depicted scene. The experiment consisted of three blocks of 30 trials lasting approximately 40 min (Figure1). IAPS images were matched on valence and arousal ratings across blocks. Stimuli order was randomly determined within each block. Participants were instructed to view the images naturally, as if they were watching a slideshow. Pupil size and gaze position were measured during the entirety of the trial.

Table 1. Summary of participant data.

	Healthy Controls	Depressed
Participants, n	46	47
Dropped due to poor data quality (%)	3 (6.5%)	4 (8.5%)
Women (%)	33 (76.7%)	34 (79.1%)
White (%)	20 (46.5%)	25 (58.1%)
Mean Age (SD)	23.8 (5.3)	25 (9.7)
Mean CESD (SD)**	4.5 (3.5)	40.2 (8)

Note: * < .05, ** < .01

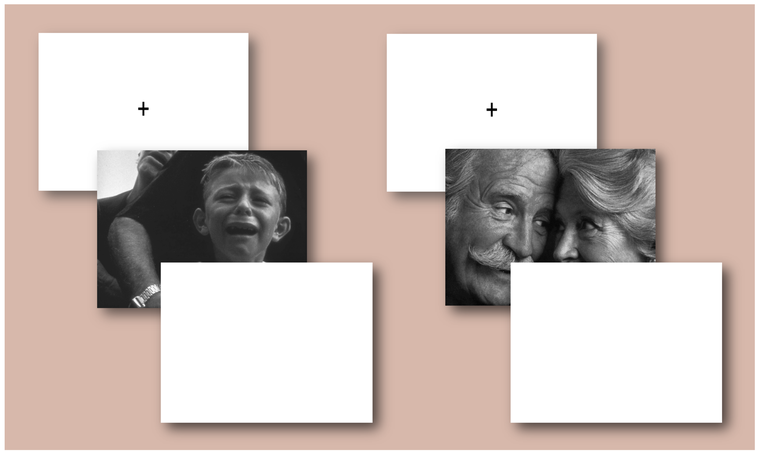

Figure 1. The task involved sequential presentation of 90 scenes selected from the International Affective Picture System[6]. Each trial began with the appearance of a central fixation cross for 2000 msec to standardize the starting location of their gaze, followed by a visual stimulus for 2000 msec, and finally a blank screen for 1000 msec before beginning the next trial.

Results

Depressed individuals exhibited significantly increased and sustained pupil dilation to negative stimuli compared to controls (Figure 2). In the depressed group, negative stimuli were also associated with greater pupil dilation when compared with neutral stimuli (but not positive stimuli)(Figure 3).

When looking at the effects of arousal instead of valence, the depressed group showed greater and more sustained pupil dilation to low arousal stimuli compared to controls (Figure 4). Finally, both the depressed group and the control group displayed greater pupillary response to high arousal stimuli compared to low arousal stimuli.

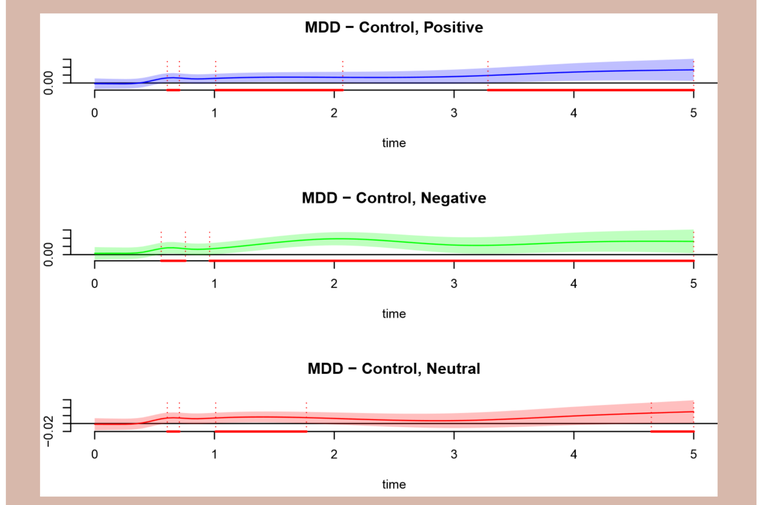

Figure 2. Graph depicts the difference in pupil dilation across the time course for MDD versus controls for the different valences. The data showed no major differences between groups for the neutral stimuli (small effects at the beginning of the trial); some early and later stage dilation differences for positive stimuli (small effects here as well); and fairly consistent differences for negative stimuli throughout the trial. Effects are most robust for the negative stimuli.

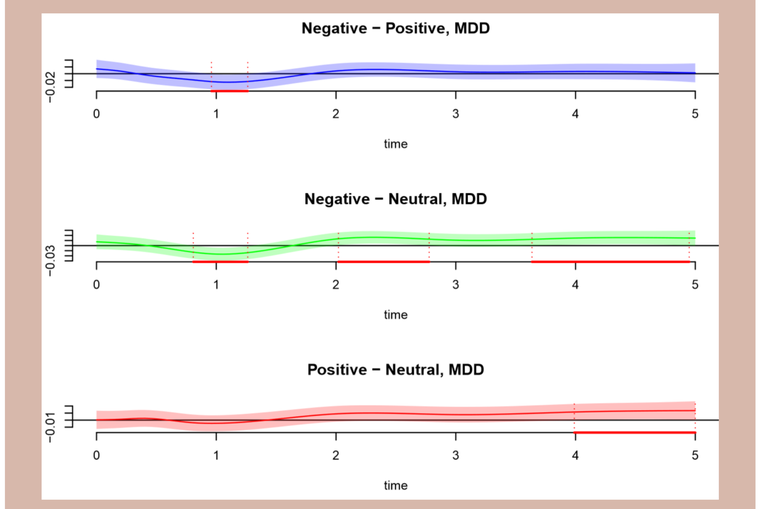

Figure 3. Depicts the effect of valence within the MDD group. The plot indicates that that the MDD group shows greater pupil dilation to negative stimuli.

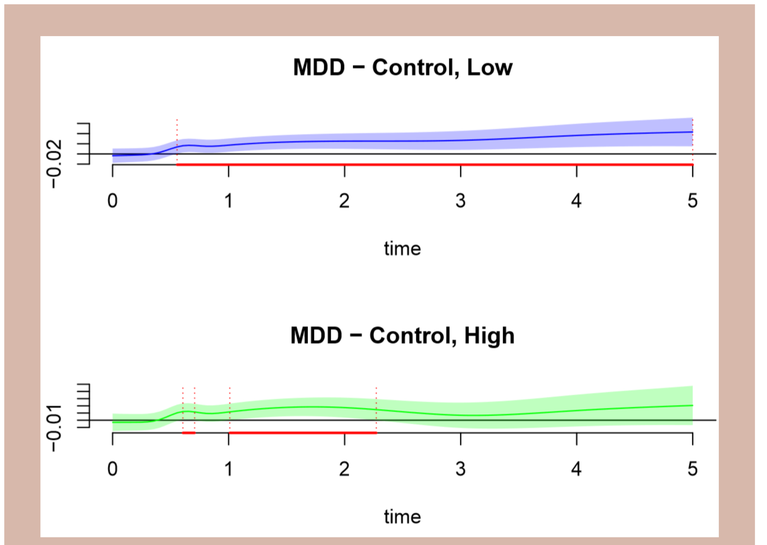

Figure 4. Graph indicates that the MDD group shows greater pupil dilation to low arousal stimuli.

Conclusions

The current study found depressed individuals show sustained, increased pupil dilation to negative complex scenes relative to healthy controls. In addition, depressed individuals exhibit persistent, increased pupil dilation to low arousal stimuli relative to controls. These findings provide additional evidence for specific, sustained cognitive processing of negative information in depressed individuals, both compared to controls and to neutral information, and suggest that depressed individuals may be more reactive to low arousal stimuli in general.

Given the complexity of these scenes, future studies ought to utilize eye-tracking to more directly understand how depressed individuals direct their attention in complex emotional scenes, and how this deployment influences pupillary response compared to healthy controls.

Contact

Rochelle Stewart
Institute for Mental Health Research
The University of Texas at Austin
Email: rochelstewart@utexas.edu
Phone: 512-232-4750

References

1. Beck, A. T. (1967). *Depression: clinical, experimental, and theoretical aspects*. New York: Hoeber Medical Division, Harper & Row.
2. Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin*, *91*(2), 276-292. doi:10.1037/0033-2909.91.2.276
3. Janisse, M. P. (1974). Pupil size, affect and exposure frequency. Social Behavior And Personality, 2(2), 125-146. doi:10.2224/sbp.1974.2.2.125
4. Siegle, G. J., Granholm, E., Ingram, R. E., & Matt, G. E. (2001). Pupillary and reaction time measures of sustained processing of negative information in depression. *Biological Psychiatry*, *49*(7), 624-636. doi:10.1016/S0006-3223(00)01024-6
5. Siegle, G. J., Steinhauer, S. R., Carter, C. S., Ramel, W., & Thase, M. E. (2003). Do the Seconds Turn Into Hours? Relationships between Sustained Pupil Dilation in Response to Emotional Information and Self-Reported Rumination. *Cognitive Therapy And Research*, *27*(3), 365-382. doi:10.1023/A:1023974602357
6. Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). International affective picture system (IAPS): affective ratings of pictures and instruction manual. Technical Report A-6. Gainesville, FL: University of Florida.